

Assignment of accession numbers by block also permits development of computer programs to provide for printout of only that portion of the system pertinent to a given department. For example, if the second department wants hard copy for preparation of a Coordinate Index for only its documents, the computer can be programmed (a) to print out only those term-roles under which are posted documents numbered 100,001 to 200,000 and (b) under those term-roles, to print out only item numbers plus links if they are greater than 100,000 and less than 200,001.

• Adaptation to Patent Information

The concept coordination technique using links and roles is currently being used for the storage and retrieval of patent information. A simple modification has been developed to permit indexing of patents so that information in claims may be differentiated from that which is contained in disclosures, specifications, and examples. First, the claims are indexed using links of two letters, CA, CB, CC, CD, etc., as necessary to cover the conceptual relationships therein. Then the disclosures and examples are indexed, using additional term-roles as necessary to expand on that which was claimed. These additional term-roles are indexed in "D" links, such as DA, DB, DC, DD, etc., using link DA on those terms which expand upon the terms in claim link CA, link DB on those terms which expand upon link CB, etc. Thus links CA and DA represent an A link. The CA terms describe the claims and the DA terms describe additional information discussed only in the disclosure. There may be links which contain only "C" or only "D" terms if the information is all in either the claim or disclosure.

This approach makes possible the indexing of rather complex chemical process patents in an average time of less than one hour.

• Summary

The concept coordination approach used in the Polychemicals Department system, as described in this paper, is an effective tool for providing access to recorded information. The information contained in documents included in this system has been made accessible to scientists for what we believe to be $\frac{1}{4}\%$ to $\frac{1}{2}\%$ of the research expenditure necessary to develop the information. Eventually, as procedures and methods are improved, the cost may be reduced to as little as $\frac{1}{10}$ of 1%. The objectives of this functioning system have been demonstrated. They are (1) to provide to scientists recorded information pertinent to their current research efforts, and (2) to minimize the unintentional duplication of research effort.

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Special Considerations of the Individual as a User, Generator, and Retriever of Information¹

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I would like to remove at the outset a possible erroneous expectation which the title may have raised. I am not going to talk about what individuals need or expect from your documentation systems. The purpose of this paper is to bring out a basic sort of relatedness between your discipline and a separate discipline which is needed relative to the individual's information-handling problems. I want to invite you to consider turning some of your talents and activities toward these problems. I would also hope to benefit from reactions and correspondence from some of you, and perhaps to discover some among you who share with me a basic conviction that more research attention should be focused upon the individual.

• About Your Systems

To help relate our two areas of interest, I will make a few observations about your systems and your discipline.

I view your systems as being designed to provide a special kind of service to certain kinds of people. When an individual composes a message to society that passes the editorial filters and becomes published, your system provides a means for distributing and storing copies of this in a way intended to make it available to other individuals who may have need for the message. The dominant challenge of your discipline involves the problem of looking back in time to see what has been contributed by others that will be of benefit to the individual of today. But you know that to help meet this challenge tomorrow, the messages of today must be stored with care.

I like to think that the objective behind the design of these systems, behind your discipline, is to increase the effectiveness of the individuals at the terminals of your systems. The intellectual labors of the individual who generates a document are made more effective by your seeing to it that his contribution becomes a "visible" part of society's growing structure of knowledge. The individuals at the user terminals of your systems are

made more effective by the ready availability of pertinent documents from the past. Your documentation systems provide an important means for cooperation among many individuals who are distributed through space and time, and the true measure of the value of your systems is the degree to which their presence serves to increase the effectiveness of the individuals at the terminals.

I wish also to comment upon the effects within your discipline that followed from the development of an automatic-information-handling technology. There appear to be mixed feelings among you as to the degree to which your future systems will be affected by this new technology. But no one denies that this technology does offer radical new possibilities throughout your systems. It seems to me that these possibilities at the very least require a complete re-examination of the entire bases of your systems, and that virtually none of the previously established techniques or procedures is invulnerable to change of a relatively radical nature. Without re-evaluation, what has evolved in a human-limited information-handling environment cannot safely be assumed as necessary in the new machine-augmented environment.

• About Individuals

Let us consider why individuals might justify special concern on the part of information-handling-system researchers. For this purpose, there is something which can be gleaned directly from your personal experience. Most of you are oriented toward solution of a documentation problem and, therefore, are yourselves problem-oriented people. Pose this question to yourselves, then: "Who makes the actual effort that results in each step of progress in your field?" In the final analysis, it is always an individual who marshals the arguments, generates the hypotheses, provides the drive, etc., upon which each forward step is dependent. It is the problem-oriented individual who is the basic module in our intellectual community. It is his effectiveness which must be the ultimate concern of anyone wishing to see that community perform better. Many disciplines, yours among them, are contributing toward the increase of this effective-

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tiveness, but it seems to me to be quite important to give a little more direct attention to the problem-oriented individual.

To consider what has been done for the individual's effectiveness by past efforts of our learned men, I might point out that the definite and formal techniques and procedures provided us by social heritage mostly involve specialized and idealized aspects of the workload and needs of the individual. There apparently never has been an over-all or "system" approach to the problem of assisting the individual in being effective in his over-all problem-solving role. But even if there had been a previous unified discipline concerned with the over-all effectiveness of the individual in his real-life problem-solving environment, that environment today is changing rapidly enough to justify a thorough re-examination of the whole structure of that discipline. Let us turn our attention to the question of what limits the effectiveness of an individual in his professional environment. If we were to give as serious consideration to redesigning his personal system of techniques, procedures, and artifacts as you information specialists are giving to your larger systems, there would be the same type of justification for re-examining the entire present system. For example, cannot automatic information-handling technology provide just as drastic an alteration in basic possibilities within an individual's private operating system as it seems to do within your documentation systems?

I prefer not to discuss here the general problem of "doing something for the individual from an over-all point of view." My intention is to tell you that, among the several areas of the individual's needs which are not getting professional research attention, there is one particular area of need for which you people would seem to have the right sort of talents to make some contributions. I should hope that some of you might be persuaded to turn your attention to this particular problem area. If none of you choose to do so, my discussing the problem area with you still has possible value because, if there are significant developments made in this problem area in the coming years, the consequences are sure to affect the needs and possibilities of your documentation systems.

As a model for us to discuss, let us take an individual that you might consider to be typical of the users of your documentation systems. The area of his need to which I refer above might be called "documentation for the individual." I do not limit this area to the type of documentation for the individual that is associated merely with his keeping a bibliographic reference file such that he can track down any article he ever read. I speak of a more general possibility. The individual usually works with much smaller packets of information than is represented by the average paper or document. His real working stuff is composed of unit facts, concepts, considerations, etc., that he gleans from many sources. An important source, of course, is the "cannibalizing" of the documents which your systems might provide him, but a good deal of this "raw material" is

obtained by personal observation, reflection, synthesis, etc., as well as direct communication with colleagues. Our individual works in a closed domain, within which a great many such small packets of raw material fly about, being extracted, originated, compiled, transformed, integrated, compared, lost, forgotten, thrown away, etc. As a result of all of this activity upon his raw material, our individual occasionally constructs messages which he sends to the world outside his personal, closed domain, and these messages to his colleagues and to the world at large represent essentially his entire professional contribution.

One important role played by documentation (on your scale) is to provide the means whereby, in the over-all scene, a perspective can be obtained of the society, of its history, and its intellectual structure. To me this is a basic utility—when one gains the necessary perspective, he then can see where to add his contribution. But in the end, such perspective must be gained by an individual, and supplying him with all the necessary documents bearing all of the necessary information does not in itself satisfy the need for perspective. The particular perspective needed by a contributor is almost always unique, one that he must construct for himself from available or yet-to-be-found facts and concepts. He gains the picture only by laboriously fitting together new possibilities, generating or ferreting out new facts or concepts, and repeating this process until a view emerges that is compatible with the existing structure and with his desires.

No human being can hold very many concepts in his head at one time. If he is dealing with more than a few, he must have some way to store and order these in some external medium, preferably a medium that can provide him with spatial patterns to associate with the ordering, e.g., an ordered list of possible courses of action. Beyond a certain number and complexity of interrelationships, he cannot depend upon spatial-pattern help alone and seeks other more abstract associations and linkages. A way to store, retrieve, and manipulate the information within our individual's private domain, with information-packet sizes that match his actual needs (i.e., separate concepts, facts, considerations, etc.), could go far toward increasing the effectiveness of his mental capabilities to the level needed for the extended and complex problems that are the pressing ones of our day.

A system of the nature I am proposing would have many of the characteristics of the large systems that you deal with. The time constants from storage to retrieval would be shorter, the package size for information would be smaller, the number of different people involved as generators, retrievers, and users would be much smaller, the subject coverage would be smaller, and the total amount of information would be smaller—but the relative variations in time constants, nature of information packets, type of need to satisfy, etc., are still large enough to require a respectable amount of sophistication in developing a good solution to this problem. Because of

the uniformly smaller scale in the different aspects of this personal system, and because of the current fashionable appeal in my home territory of the trend known as microelectronics, I call this personal documentation problem "microdocumentation."

• An Example of a Simple Microdocumentation System

I have been experimenting in an extracurricular sort of way for the past six years with a crude bibliographic and note-filing system which can qualify as a microdocumentation system, and which can serve as an example of the sort of thing I have been talking about. I took time out of an intensive research project to settle once and for all the pesky problem of a good personal bibliographic retrieval system. I had never heard of Calvin Mooers, but with some significant hints from the writings of those who obviously had, I managed to re-invent what was essentially a Zatocoding system. This gave me plenty of power for one aspect of my research—keeping track of the documents which became involved in my study—but the very first day back on the initial research job, analyzing some of these documents and piling up notes, made me realize that a bibliographic system was only a partial solution.

Within an hour, a note-taking system was born and put into use that can coordinate nicely with almost any bibliographic system: in fact this note system has proven considerably more useful to me than has my bibliographic system. I write my notes on edge-punched cards (essentially the size of IBM cards, with about 100 peripheral holes). These cards include all the different concepts, facts, considerations, personal ideas, etc., that I come upon or generate during the working day and that seem at all useful. I put only as much on a single card as seems to comprise a separate usable information item or concept—for instance, it frequently happens that a single paragraph in a reference article will provide facts, suggestions, concepts, or stimuli for personal ideas that obviously relate to different aspects of expected future work. Such a paragraph would result in several notecards, each of which might contain only a sentence or two. I use cards very freely, because the storage and retrieval is such that superfluous notes do not really get in the way very much.

My bibliographic system gives a serial accession number to each reference source from which I take notes. When I pick up a clean card to take a new note, I write at the top the reference number and the page number, and then begin writing the note. When I am done I underline a few significant words, and sometimes write down a few relevant descriptors (not really necessary) so that when I go to this card later its basic subject content will be immediately visible. One field of the card is used to notch in the coded serial number (or at least the two least significant digits), but most of the holes are reserved for direct-code notching of descriptors. Cards are coded, stored, and searched in particular

notedecks, and each notedeck has its own set of descriptors. It has always been easy to divide my fields of concentrated interest into small enough areas that it is easy to get good retrieval specificity from a small enough number of descriptors such that one hole could be assigned to each for rapid encoding and searching. The descriptors are written on a master code card; when I have completed writing a given notecard I place the master card over it and very rapidly scan the descriptors and mark the holes on the notecard that should be notched. Beyond writing the note, the total extra time involved in choosing and marking descriptors, in marking reference-source accession-number code, and in the later notching of a given notecard is well under a minute. I feel that I have always gotten very large returns from the investment of these extra minutes.

With this system I do not have to keep my notecards in order. Also, I can very rapidly extract all of the notes from a notedeck that are relevant to any of a large number of different aspects of my work. Useless notes mostly stay in the deck, but can easily be weeded out if they become any kind of a nuisance. There is now a place for me to store the various miscellaneous ideas, possibilities, suggestions, facts, etc., that are always popping up in the day's activity. When I am immersed in one phase of my work and something stimulates a useful thought about another phase, I can quickly write it down, code it, and return to what I was doing, confident that that recent thought is integrated effectively into my activity.

I find it very productive to browse through a notedeck, integrating what I find and what is stimulated in my mind, and synthesizing new concepts, considerations, and ideas on new notecards. I make a practise of putting the date of writing on each notecard, so that the chronological ordering of the fragments of a conceptual structure that is in any stage of evolution is readily apparent.

When searching for note items, a card that falls out on descriptor selection and that proves particularly interesting gives me a reference source number. I can needle-select all other notes in the deck from this same reference to retrieve further relevant information. A good proportion of the need to retrieve original reference documents that have once been "digested" (i.e., that have any notecards in one or more notedecks) is met very easily by a little needlework on one or more appropriate notedecks, and following up on a few accession numbers from the selected cards. This reduces considerably the demands upon my bibliographic filing system. When writing a paper and using direct information from some notecard, the footnote acknowledgment is captured merely by writing down the reference accession number, and letting a secretary fill out the full referencing later.

There are many things about this system that could be improved, but it offers considerable value to me as it is, and my purpose in describing it here has been

to provide a crude but real-life example of the sort of thing I mean when I speak of need and possibilities for microdocumentation. To continue this "backyard" experimentation on a little more effective level, I am bringing in a second party—my microdocumentalist if you wish—to help me develop and operate an improved system. It is clear to me, however, that development of really good microdocumentation systems will take much more research than this effort represents.

• About the Future

A microdocumentation system involving edge-notched cards, wherein the user does his own clerical work, has already proven worthwhile in my own case, and it may very well prove quite beneficial to a large class of individuals. I feel, however, that clerical help with the routine parts of the system operation will prove worthwhile and will expand the possibilities for designing a truly useful system. Further, the development of some simple special equipment to facilitate transcription, coding, and selection of the cards could produce even greater system improvements. I feel sure that in today's economy, with today's capability in equipment design and production, we can devise economically justifiable microdocumentation systems that would considerably improve the ability of the individual to collect and integrate the information necessary for gaining perspective and finding solutions in complex problem areas.

I feel even more sure that the future will see some very radical changes in the techniques and procedures with which our professional individuals pursue their daily work. It is not hard to see a number of ways in which automatic information handling equipment can be utilized in a microdocumentation system. Just as in "macrodocumentation," the nature of the possibilities offered by this equipment is such as to justify a complete re-examination of essentially all of the techniques and procedures which we have inherited and which we consider "the natural way to go about our intellectual activity." Other areas of the individual's intellectual activity, besides his microdocumentation system, are going to experience a similar and coordinated kind of radical change. For instance, the detailed manipulations of symbolic information which accompany our more sophisticated thought processes, and which are now done manually, will be receiving attention similar to that given to the area of microdocumentation. Any dynamic man-computer relationships developed for aiding these sophisticated thought processes will involve techniques and procedures which will be profitably coordinated with those of the microdocumentation system.

That our technology does not now offer us directly the means for implementing advanced microdocumentation systems is not entirely because it would be beyond present capability. Generally speaking, developmental efforts have been applied toward other special applications, but the basic technology could provide us with

much that would be economically beneficial to such as microdocumentation systems, if this sort of application became of interest to product development people. The real bind in early development of some truly exciting systems lies in the research needed in the organizational and procedural aspects of the problem.

You might give thought to the way in which an individual, whose basic capabilities have been "augmented" by a good microdocumentation system, would have his needs for service from your systems affected. Perhaps more important even, would be the new capability this individual, would exhibit in ferreting out needed information from any of your systems.

I have often made the unsubstantiated but serious challenge that the money spent on the big retrieval and scientific communication problem would bring greater returns to the same end by being spent on developing really good systems for the individual. I think I could offer reasonable defense of this position even if it were assumed that microdocumentation were to be the only "individual" system involved—but my defenses would be considerably stronger if we included other areas of aid to the individual. The individual's systems present a much more manageable problem. I claim that we would be able to solve the big problem much more easily and cheaply if we took care of the "basic modules" first (individuals), and that also we would get the huge bonus of providing significant improvements in the effectiveness of the individuals in their direct working environment.

There are several good papers to which I would like to call your attention, which present various associated and supporting views regarding special aid for the individual. The most directly relevant is one that many of you may already be aware of, a paper by Vannevar Bush (1), whose arguments of fifteen years ago could hardly be bettered for today's case. I. J. Good (2) and J. C. R. Licklider (3) present relevant and very stimulating thoughts, also.

• Conclusions

Man-machine cooperation appears to be a big factor in the possibilities for making over-all gains in the effectiveness of individuals. There are trends already developing toward new means of communication such that a human can better transmit signals to a computer; research on display devices is active; and the programming researchers are making rapid gains in developing good languages or signal codes so that an individual can easily give directions to the computer to do his bidding. There is also a significant trend toward computer and programming systems that allow time-sharing of large and powerful computers on a demand basis by many users, which promises to reduce the cost of sophisticated service to an individual toward an economically realizable level.

Your field of "macrodocumentation" should not lose sight of the pressures, from other computer applications, toward developments of closer man-computer cooperation. For instance, it will not be up to you alone to decide whether or not it will be stylish or practical to have the individuals who use your systems learn special communication techniques, special languages, and special procedures for working with machines. These things are very likely to be brought into the picture independently. Remember that most individuals spend a lot more time suffering because of the problems in their own little domains than they do being aware of problems in the "macrodocumentation" service. Giving consideration to this makes it seem inevitable, for instance, that your documentation systems will go in the direction of using cooperative man-computer efforts, and that we will see the evolution of special formal languages to be used operationally in your systems.

Admittedly, these thoughts relate to rather distant times, and consideration of users who have been provided with streamlined personal information-handling techniques is not necessary in the system problems that concern you today; however, there may be some long-range worth in bringing up such considerations at this stage. There are shorter-range possibilities stemming from this type of argument that could affect the course of some of the systems under development today—the individuals who are part of the operating structure of your systems, specialists (e.g., indexers, search experts) whose activity is more limited than the general problem solver, and for whom special training and special equipment may earlier be practical, could very well be given some of the same individualized types

of techniques, procedures, and equipment service which I predict our more independently operating problem-solving individual will later be using.

This makes three ways in which my vision of future development may affect you: you might expand the boundaries of your discipline to help develop good general microdocumentation systems; you might develop specialized individual systems of this nature to make better use of the human capabilities within your own systems; and you might expect the needs and possibilities for your future systems to be affected by the "augmentation" of the individuals who are to be the system users. I have found in your literature of late several references to the possibility of a new professional specialist emerging—an "information scientist" who can join a research group and take care of the search and analysis of pertinent literature. It might be that this type of an individual could also be trained as a microdocumentation specialist, too, so that he can do his own work better and so that he can help his colleagues set up and operate their own personal systems.

Perhaps next time we shall meet at a conference of the American Microdocumentation Institute?

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